

# DOCUMENT RESUME

ED 059 069

SE 013 238

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TITLE The National Engineers Register: A Final Report.  
INSTITUTION Engineers Joint Council, New York, N.Y.  
SPONS AGENCY National Science Foundation, Washington, D.C.  
PUB DATE 31 Dec 71  
NOTE 13p.

EDRS PRICE MF-\$0.65 HC-\$3.29  
DESCRIPTORS \*Directories; \*Engineers; \*Occupational Surveys;  
\*Reports; Surveys  
IDENTIFIERS \*Engineers Joint Council

## ABSTRACT

This report summarizes the experience of Engineers Joint Council (EJC) in operating the National Engineers Register under contract with the National Science Foundation as part of the National Register of Scientific and Technical Personnel. EJC has also included its recommendations for the most effective operation of a national roster of engineers whenever such is required at a future date. Described are: the history of society involvement, criteria and coverage of engineers included in the register, national register operations, alternatives to a national engineers register, and recommendations for improving the system. (Author/TS)

ED 059069

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# THE NATIONAL ENGINEERS REGISTER

## A FINAL REPORT

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December 31, 1971

Foreword. This report was prepared under the terms of contract NSF-C407, Amendment 6, to summarize the experience of Engineers Joint Council in operating the National Engineers Register under contract with the National Science Foundation as part of the National Register of Scientific and Technical Personnel. EJC has also included its recommendations for the most effective operation of a national roster of engineers whenever such is required at a future date.

This report was written by John D. Alden, Director of the National Engineers Register from mid-1965 until its termination on December 31, 1971.

## The National Engineers Register - A Final Report

### I History of Society Involvement

Engineers Joint Council's association with the National Engineers Register began in 1954 with the initial establishment of the National Register of Scientific and Technical Personnel under auspices of the National Science Foundation. Prior to that time EJC and its predecessor organizations had been associated to various degrees with earlier counterparts of the National Register. EJC's participation was based on its chartered purpose to act on behalf of its constituent engineering societies in matters of joint interest. The relationship was unique among the societies participating in the Register in that all of the other participants were scientific societies representing their own individual disciplines, whereas EJC alone was able to represent the entire engineering profession through its contacts with the numerous disciplinary societies making up the organized profession.

The unique role of EJC was reflected in the contractual arrangements and funding of the NER in that EJC has no individual members (its members are engineering societies) and therefore had no membership list of its own to maintain, except between 1968 and 1970 when it maintained a mailing list for its bimonthly magazine ENGINEER. During most of EJC's period of operating the NER, NSF reimbursed it for the costs incurred. The individual engineering societies received no support for maintaining their own membership lists, consequently there was a distinct separation between activities conducted on behalf of NSF and those on behalf of the engineering societies and their members. Between 1968 and 1970 EJC maintained its ENGINEER mailing list at its own expense, and charged NSF only for the direct costs involved in selecting and printing the sample of names to be surveyed in 1969.

From the viewpoint of EJC and the participating engineering societies this relationship was necessary to protect the integrity of their membership lists. Ownership of the names and addresses constituting the NER was vested in EJC, not NSF, whereas NSF under the terms of its contracts obtained ownership of the data obtained through the various NER surveys. Without the protection of members' names and addresses possible through this arrangement, many societies would have flatly refused to participate and the effectiveness of the Register would have been greatly diminished.

### II Criteria and Coverage of Engineers Included in the NER

All so-called engineering societies include among their members a greater or lesser number of individuals who might be classified as scientists, managers, technicians, or simply people interested in the field of technology represented by the society. In order for a society to become a member of EJC at least 50% of its individual members must be graduates of an accredited engineering curriculum at the bachelor's level or higher. The bachelor's degree is not, however, a necessary prerequisite to professional recognition as an

engineer. Engineering has traditionally been entered on the basis of demonstrated ability. The membership criteria of most engineering societies require that the applicant present evidence of a certain number of years of responsible practice of engineering, and accept education as a partial substitute for the required experience. In past year it was quite common for talented people to earn widespread recognition as leaders in engineering without having a full formal education. State laws require that some but not all engineers be licensed before they can practice in certain functions involving the public safety. Licensing or registration is based on an examination, and in many jurisdictions graduation from college is still not mandatory.

In order to be included as an engineer for purposes of NER statistics, a respondent had to meet at least one of the following criteria:

- a. Be a graduate of an engineering curriculum at the bachelor's level or higher;
- b. Be registered as a Professional Engineer or Engineer-in-Training in a state or territory of the U.S.;
- c. Hold full professional membership in a society requiring the demonstration of professional competence as a condition of membership.

The first two criteria are easily applied in a register survey, but the last in the final analysis requires individual screening and judgment. Fortunately the percentage of borderline cases is small and these were always handled without great difficulty.

It is impossible to know exactly how many engineers there are in the U.S., partly because of definitional problems and partly because many people educated as engineers move into other occupations such as business executives, contractors, military officers, educators, scientists, patent lawyers etc. Many qualified engineers do not belong to organized societies and thus cannot be reached through surveys of society members. EJC estimates that between 50 and 60 percent of all engineers are members of at least one society, and that the various NER surveys represented between 40 and 50 percent of the U.S. engineering community depending on the number of societies included in each survey.

The number of subprofessionals is estimated to be between 5 and 10 percent of the total engineering society membership, with a similar number of scientists or other nonengineering professionals.

### III National Register Operations

A. Background. As far back as the Civil War, Congress recognized the need for a national registry of individuals with scientific and engineering skills so that people could be identified and located in time of national need. Central listings of such people were established during World Wars I and II and maintained under various names until 1953. In that year NSF became responsible for the National Register of Scientific and Technical Personnel. The engineers' portion of the Register was maintained by EJC under con-

tract with NSF. From 1954 to 1964 the NER consisted only of a "finders list" of about 20,000 prominent engineers, under the theory that key individuals could be identified who would be able to act as "finders" of engineering talent in a national emergency.

The "finders list" concept was obviously inadequate to meet the second major objective of the National Register, namely to serve as a source of statistical data on the U.S. engineering community. In order to meet the statistical objectives NSF contracted with EJC to expand the Register to a more representative cross section of the engineering profession and to conduct periodic surveys based on a statistical sample of the population. Three such surveys were conducted in 1964, 1967, and 1969. A fourth survey planned for 1971 was cancelled, but much of the planning was utilized in the national survey of engineering employment conducted in July and August of 1971. All surveys used different methodologies and thus provided a wealth of experience in operating a register of engineers.

#### B. Effectiveness of the NER as a National Emergency Manpower Locator.

Although the Register was never called upon in this role, it is apparent that it could have functioned only imperfectly because of structural limitations. The basic requirements of a locator system are that it be a complete list of names, that key characteristics of individuals be identified, and that the addresses be kept up to date. These conditions were never met during the history of the NER.

During the "finders list" stage major characteristics of the registrant were identified and their addresses were kept reasonably current, but the list was far from complete.

From 1964 to 1971 the NER consisted of a random sample of names drawn from the membership rolls of various engineering societies. Characteristics of about 60,000 respondents were coded on magnetic tape, but there was no way of keeping the addresses current. Immediately after each survey the names and addresses would be reasonably up to date, but by the end of two years (the intended survey cycle) many would have become obsolete. The Register was therefore never complete nor was it fully up to date during much of its existence between 1964 and 1971.

#### C. Effectiveness of NER as a Source of Statistics on the Engineering Community.

When the NER was merely a "finders list" it was obviously not representative of the U.S. engineering community and was therefore of little value as a source of statistics.

The mailing lists used as the basis for the samples surveyed in 1964, 1967, 1969, and 1971 were quite extensive but in no case could they be considered representative of the entire engineering community. Rather, they were representative of the membership of various combinations of engineering societies. There are literally hundreds of organizations that can be charac-



terized more or less accurately as engineering societies in a professional sense, perhaps 60 of which are of national importance. In many of them the areas of interest overlap, so that there is a significant degree of multiple membership among the societies as a group. Between any two societies the degree of dual membership can vary from practically none to perhaps 80 or 90 percent. The more societies that are combined in a group the greater is the probability that members of an unincorporated society will already be members of one or more of the combined group. Because of this it is possible to obtain a rough representation of the organized engineering community by combining the memberships of the major engineering societies only, at the risk, however, of omitting some small but specialized groups.

Unfortunately, many engineers simply are not members of any engineering society. Therefore a list made up of only society members is probably not completely representative of the engineering community. Non-members could be reached by using college alumni lists, state engineering registration records, employers' records, or publicity in technical magazines. Several of these methods were investigated by EJC and determined to be feasible, but none was ever actually used to expand the NER.

Once the basic limitations of the population being sampled are understood, it is possible to use various techniques to draw a sample and obtain statistical data. The different methods used in the EJC surveys, with their advantages and disadvantages, are discussed below.

1. The 1964 NER Survey. The 1964 survey population consisted of the memberships of 41 societies with combined individual memberships of 678,000. Each society mailed a questionnaire to every sixth name from its own membership list. No effort was made to eliminate duplicates, i.e. individuals whose names were provided by more than one society. Because of this there was no way of knowing how many non-respondents were actually duplicates, and the survey statistics could not be expanded with any degree of confidence. The advantages of this method were simplicity and speed in obtaining the names and addresses. Disadvantages, besides the problem of statistical control, included the difficulty of deleting respondents from the follow-up mailing, the extra postage and handling spent in duplicate mailings, and the poor impression created by sending multiple questionnaires to a fairly large number of people.

2. The 1967 NER Survey. The 1967 survey population consisted of 45 engineering societies with combined individual memberships of about 712,000. Each society provided EJC with a sample consisting of every seventh name from its membership list. These names were merged into a single alphabetical deck and duplicates were removed before questionnaires were mailed. The address label of each person surveyed was coded to indicate all of the societies that had included his name in their sample. The resulting statistical control made it possible to expand the survey sample results to represent the entire population covered, and to represent the members of each society individually. The 1967 survey was the best ever made for the NER in terms of breadth of coverage and statistical refinement. Unfortunately no detailed statistical cross tabulations were ever produced from the excellent body of data made available. The

only disadvantages of the method used in 1967 were the tedious manual effort required to produce the unduplicated deck, and the extra costs and delay associated with this phase of the work. EJC also made a third mailing to everyone who had not responded to the two regular mailings. This mailing used an abbreviated questionnaire form. Although an excellent response was received, the returns were not included in the data analysis by NSF.

The 1967 survey also included a mailing to approximately 60,000 1964 NER respondents. Duplicates between this list and the society sample were removed. The questionnaires for this group were pre-printed by computer to show what data had been provided in 1964. Even though the addresses used were about three years old, we received a response rate of 90% to this part of the survey.

3. The 1969 NER Survey. The 1969 survey was made under stringent financial limitations. The basic population sampled was a list of 315,205 names representing 17 societies, which had been prepared by EJC as a mailing list for its bimonthly magazine. This list was already unduplicated. A sample was drawn consisting of every fourth name from this list. This was then augmented by separate samples from two additional societies not included in the basic list. Only one follow-up mailing was made. The advantages of working from an existing master list included greatly reduced preparation costs and the ability to draw a sample on short notice. The disadvantage was that the list was less representative than in either of the previous surveys and had to be augmented by names from other societies, which introduced statistical control problems. In fact, the data from one of the additional societies had to be excluded from the final results. In order to expand the results to represent the entire population sampled, weighting factors were developed by NSF to account for multiple memberships and variable response rates among the 18 societies included.

4. The 1971 Survey. The 1971 national survey of engineering employment, although not strictly an NER survey, deserves mentioning because it used methods that would have been applicable to the NER. As in 1969 the basic population consisted of the EJC mailing list. Although this list was no longer being kept current after the suspension of publication of EJC's magazine, EJC was able to update and expand it by adding address changes, new society members, and the membership lists of additional societies, so that the final population sampled consisted of approximately 500,000 unduplicated names representing 23 engineering societies. Questionnaires were mailed to every fifth name from the master list. One follow-up mailing was made about four weeks after the first mailing.

The statistical results of the four surveys are summarized in Table 1 attached. It is impossible to determine the precise degree of reliability with which these surveys represented the population sampled, because no study was ever made of the non-respondents. However, there are several circumstances that support a feeling of confidence in the results. First, the statistical data have been generally consistent from survey to survey. Second, data on the members of particular societies derived from the overall survey returns have been consistent with information already known by these societies from their own records. Third, the extra mailing made in 1967 produced the remarkably



high response rate of 86%. Visual observation of these returns indicated that a high percentage had not replied to the first two mailings because they were retired or did not consider themselves engineers. Fourth, a very small follow-up in 1971 confirmed that a high percentage of non-respondents were retired or non-engineers, and indicated that the others closely resembled respondents in terms of major characteristics investigated. It is therefore reasonable to conclude that the NER survey results are representative of the engineering society membership population at least in terms of broad characteristics, and that in comparison with the total U.S. engineering community this group is probably somewhat better educated, more professionally oriented, older, more experienced, and more managerially oriented.

D. The NER as a Source of Longitudinal Data. Because each NER survey was made on a random sample of the population studied, survey data were of little value in tracing the career paths of individual engineers. Also, changes in the survey population and methodology from year to year tended to make interpretation of longitudinal changes in characteristics unreliable. It should be noted, however, that the capacity of the system was never fully exploited. As a result of the 1964, 1967, and 1969 surveys, detailed characteristics were ascertained on about 180,000 individuals. This information, or key parts of it, could have been permanently keyed to a name and address file so as to build up a gradually increasing inventory of data on the population. Instead, each survey sample was treated separately and independently, and the information can be identified only with the address of the respondent at the time the questionnaires were filled out.

E. Development of Specialties Lists. It became apparent early in the operation of the NER that engineers could not be categorized by a single specialties list. Instead a profile system was devised in which each respondent was categorized according to the field of his education, the products or services with which he worked, the areas of technology in which his expertise lay, and the work functions that he performed.

The lists were originally developed by analyzing the areas of interest represented by engineering societies and their sections, subsections, and committee structures. These were expanded by the addition of terms suggested by many knowledgeable individuals from the engineering societies and were later refined on the basis of survey results. Although data from the 1964 survey indicated that changes would be desirable, the same specialties lists were used in 1967 for reasons of expediency. The lists and the entire profiling system were thoroughly reviewed and revised for the 1969 survey. For the 1971 employment survey a greatly simplified system was used based on the previous specialties lists as modified by experience with the 1969 survey.

F. Survey Mechanics. Because EJC does not have a mail handling facility of its own, and none of its member societies has the capacity for handling mail in excess of its own requirements, EJC has always used commercial mail houses and list maintenance organizations for the NER surveys. Actual mailing operations are relatively simple and were therefore awarded to the lowest re-

sponsible bidder. List maintenance is a more sophisticated matter involving special provisions to meet the requirements of the client. Once a list operation is set up it cannot be shifted to a different supplier without causing many problems. EJC selected its list maintenance house on the basis of investigation and negotiation followed by the establishment of firm unit prices for repetitive operations.

Duplicate names were removed manually in 1967 and 1969, and by a proprietary computer program in 1971. Such a program should be followed by manual screening, but time did not permit doing this in 1971. Purely manual unduplication is extremely cumbersome, time consuming, and uneconomical, and should be avoided in an operation as extensive as the NER.

EJC carried out the coding of questionnaires on its own premises (rented for the purpose) and with its own employees, including many temporarily hired for the purpose. College students on vacation were by far the most satisfactory coders and the most readily hired when the timing was appropriate. Security of the questionnaires was provided by simple locked storage arrangements. Individual questionnaires are inherently of no value to a thief, although their disclosure to unauthorized persons should obviously be avoided. EJC would prefer to keep the names and addresses separate from the data section of the questionnaire, using an identification number to relate the two parts. Time and funding limitations prevented using this method on any of the NER surveys. Protection of the complete mailing list is the most important security consideration and one that EJC has taken great pains to achieve in its dealings with list maintenance and mail houses.

Follow-up mailings were controlled by printing a duplicate deck of envelopes or address labels, pulling out the duplicate when a return was received, and mailing the remainder at a predetermined time, usually three to four weeks after the initial mailing. When the list is computerized in zip code order or alphabetical order this is a relatively simple task. Zip code is preferred for ease in mailing. The most successful results were experienced when this task was contracted to the mail house. In 1964 and 1967 EJC did the job manually on its own premises, and experienced many difficulties because of the sheer volume of clerical work involved.

#### IV Use of Manpower Information by Societies.

Because of EJC's unique relationship to NSF and the cooperating engineering societies, there was no occasion to use the NER for identifying individuals. Such use would have been limited because the NER list was never more than a sample of each society's membership.

Statistical information from the Register was always of great interest, especially when broken down into cross-tabulations as in the case of the 1969 data. It has always been a matter of regret that cross-tabulations were not provided by NSF from the 1967 data, which were based on the most representative population ever surveyed under the NER. NSF also provided data tabulations broken down by society membership, which EJC passed along to the participating

societies. These tabulations were received with interest and usually published by each society in its own journal or newsletter, thereby generating good will and cooperation on the part of all concerned. Reports such as Engineering Manpower in Profile were widely distributed as sources of general information on the engineering profession.

#### V. Alternatives to a National Engineers Register.

Because of the fragmented nature of the engineering profession, there is no convenient single source of a comprehensive list of names and addresses. Any master register must therefore be put together by combining available lists of names and addresses. Employment statistics and educational statistics, while useful, are not an acceptable source of data on individuals and therefore are useless in fulfilling the locator function of the NER and of only limited value in fulfilling the statistical function.

Census data, particularly the kind provided by the post-censal surveys supported by NSF, could provide statistics of great utility. EJC supports studies of this kind. Census information, however, cannot be used for locator purposes. Also, the ten-year interval between censuses is too long to provide the kind of data needed to keep abreast of trends in rapidly changing fields such as science and engineering. Post-censal studies are a valuable complement to a national register but not a substitute for one.

#### VI Recommendations for an Improved Register System.

A truly effective national register of engineers which would serve as a personnel locator in time of national emergency as well as a valid source of statistics on the engineering community, should incorporate the following principles:

- a. Continuous or frequent periodic input of new entrants to the profession.
- b. Periodic updating of addresses, preferably such that no address would be more than one year old.
- c. Permanent storage of key data on individual respondents, keyed to the individual's current address.

The basic source of names and addresses would be the membership records of the major U.S. engineering societies. Many of these are maintained on computers and can be merged into a master list quite easily. Others require conversion from addressograph plates, cards, or special computer systems to a standardized format. Commercial facilities for merging, unduplicating, and updating a master list of this sort are now available, at reasonable prices, and were successfully used by EJC for the 1971 survey.

The master list should be expanded by adding engineering college alumni

lists and lists of state boards of engineering examiners. EJC investigated these sources in 1969 and found that out of 195 schools that replied, only 35 did not have such lists or would not make them available. In the case of the 46 state boards that responded only two would not provide rosters of registered engineers in some form.

In addition to these existing lists, all newly graduating engineers should be contacted via the deans or other officials of their schools. EJC regularly receives enrollment and degree data from all U.S. engineering schools and would receive excellent cooperation in reaching prospective graduates.

Finally, engineers not reached in any other way could be sought by notices published in the technical press or through employers, with whom EJC has excellent relations.

The foregoing methods would assure thorough coverage of the U.S. engineering community and continuous input of new entrants to a master list to be used as a basis for statistical surveys.

The necessary updating of addresses could be accomplished by a combination of methods. About half of the changes could probably be obtained from the major societies, which update their own lists regularly and are willing to provide the changes to EJC. People not covered in this way would have to be reached by annual mailings. These should be spread out over the year using the least expensive postal rate available. First class mailings would be necessary only in the case of those who failed to respond. All survey mailings should, of course, be first class.

In order to maintain a record of the most recent data on individuals listed in the register, the name and address tape should include a permanent identification number which would remain associated with the data file regardless of address changes. Key characteristics such as year of birth, field and level of college degree, and society memberships could also be stored in fields on the same tape as the name and address in order to permit selective mailings when desired. This would also prevent going back to non-engineers, retired persons, and others whose responses were unusable in previous surveys.

Operation of a register along the lines described above would have the additional advantage of requiring a small but steady work force in contrast to the cyclical demands of the NER surveys. These necessitated recruiting and training fifteen or twenty temporary workers for each survey, renting additional space and equipment, contracting for special one-time computer services, and in general going through an uneconomical buildup and reduction every two years.

In order to operate a register of this kind the government must accept the engineering profession as a partner rather than as a supplier of contracted services. Meaningful statistics can only be obtained by involving the profession in all phases of their collection and interpretation. Professional organizations

are particularly sensitive to inaccurate interpretations of statistics made by analysts not thoroughly familiar with the profession, and the poor publicity that results from such misinformation. It is obviously necessary that any use of the register as a locator device be carefully controlled to assure that the confidence of members of the profession is retained at all times.

In summary, a new National Engineers Register should be established with the objectives of providing a complete and essentially up-to-date roster of names and addresses of qualified U.S. engineers, using this list as a basis for statistical sampling of the engineering community, and keying the data thus obtained on the characteristics of individual engineers back to the address list by means of a suitable identification number. The Register should be funded and operated as a continuing rather than a sporadic activity, and it should be operated by an organization representing the engineering profession, not a government agency.



Table 1

## Statistical Summary of NER Surveys

	<u>1964</u>	<u>1967</u> <u>F/U 1964</u>	<u>1967</u> <u>New</u>	<u>1969</u>	<u>1971</u>
No. of societies in population	41	41	45	18 <sup>1</sup>	23
No. of members, including duplicates	677,958	NA	712,000	NA	NA
No. of names, unduplicated	UNK	NA	565,000	345,500	498,000
Ratio of sample	1/6	1/1	1/7	1/4	1/5
No. of names in sample	106,178 <sup>2</sup>	60,248	82,416	86,438	98,004
Total responses <sup>3</sup>	60,379 <sup>4</sup>	54,499	52,623 <sup>5</sup>	54,556	61,137
Response rate	57%	90%	64%	63%	62%
Usable responses	55,310	47,204	40,677	44,837	59,339
Qualified engineers represented	UNK	UNK	438,000	308,000	UNK

## Notes:

1. Does not include Society of Automotive Engineers with 20,000 members, surveyed but not counted in data.

2. Includes an unknown number of duplicates, which is reflected in the low response rate.

3. Only responses received up to time of survey cut-off are counted. In each survey about 5% additional questionnaires were returned late.

4. Does not include 2,469 late responses not counted in data but included in 1967 follow-up survey.

5. Does not include 11,704 replies received in response to a third mailing. Including these would give a response rate of 78%.